Future Role of carbon capture and storage: Analysis with the global ETSAP-TIAM model

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Overview

- ETSAP:
  i. Models and Tools
- Global ETSAP-TIAM model
- Scenario analysis:
  i. Variation of CO_2 price with and without availability of CCS
- Conclusions

Energy Technology Systems Analysis Programme (ETSAP)

- **Implementing Agreement of the IEA, first established in 1976**

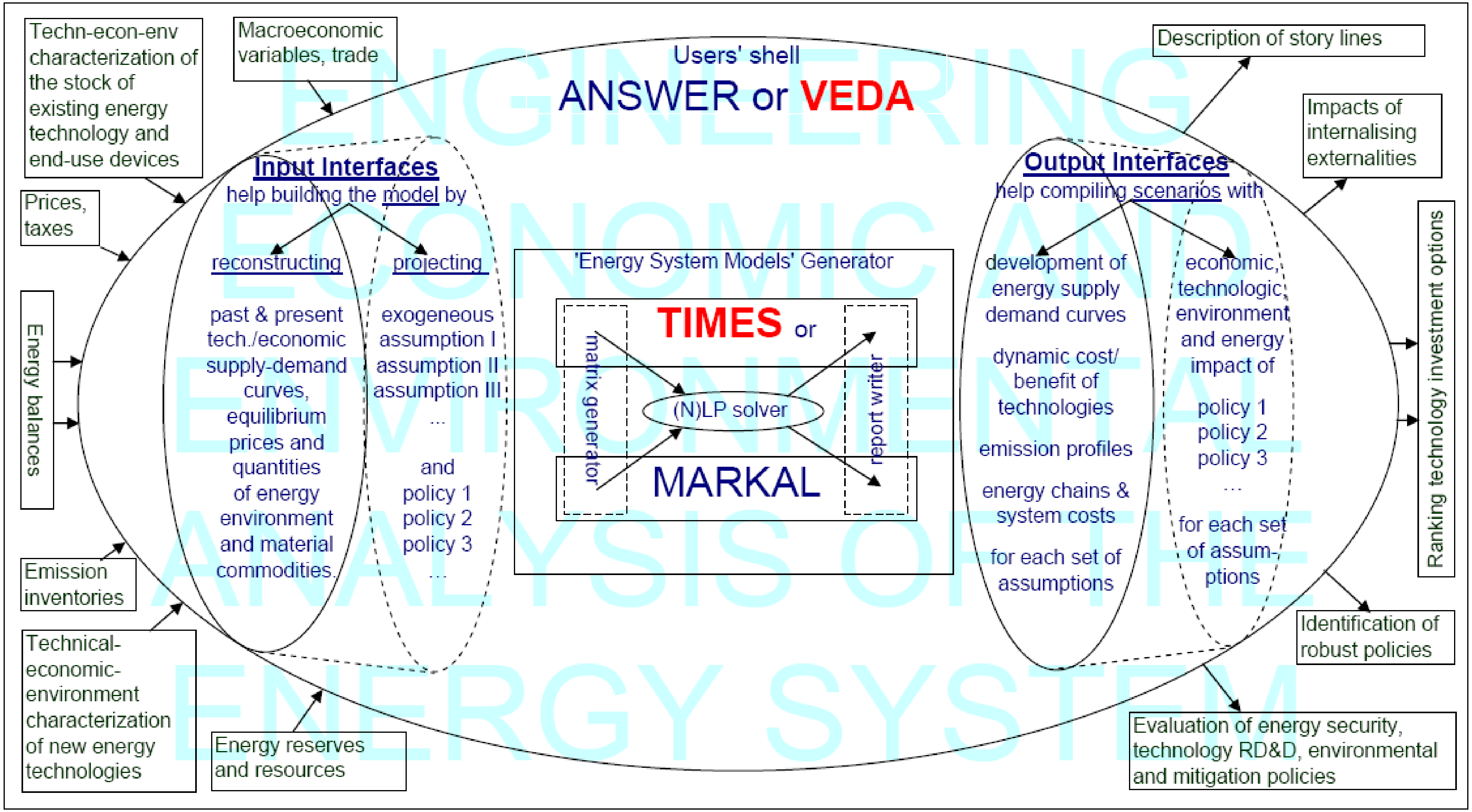
- **ETSAP's objective is to assist decision-makers in the assessment of new energy technologies and policies in meeting the challenges of**
  i. **energy needs,**
  ii. **environmental concerns, and**
  iii. **economic development,**

  by carrying out a programme of co-operative energy technology systems analysis.

- **ETSAP has established, and now maintains / enhances the flexibility of consistent multi-country energy / economy / environment analytical tools and capability (the MARKAL-TIMES family of models), through a common research programme.**

- **ETSAP members also assist and support government officials and decision-makers by applying these tools for energy technology assessment and analyses of other energy and environment related policy issues.**

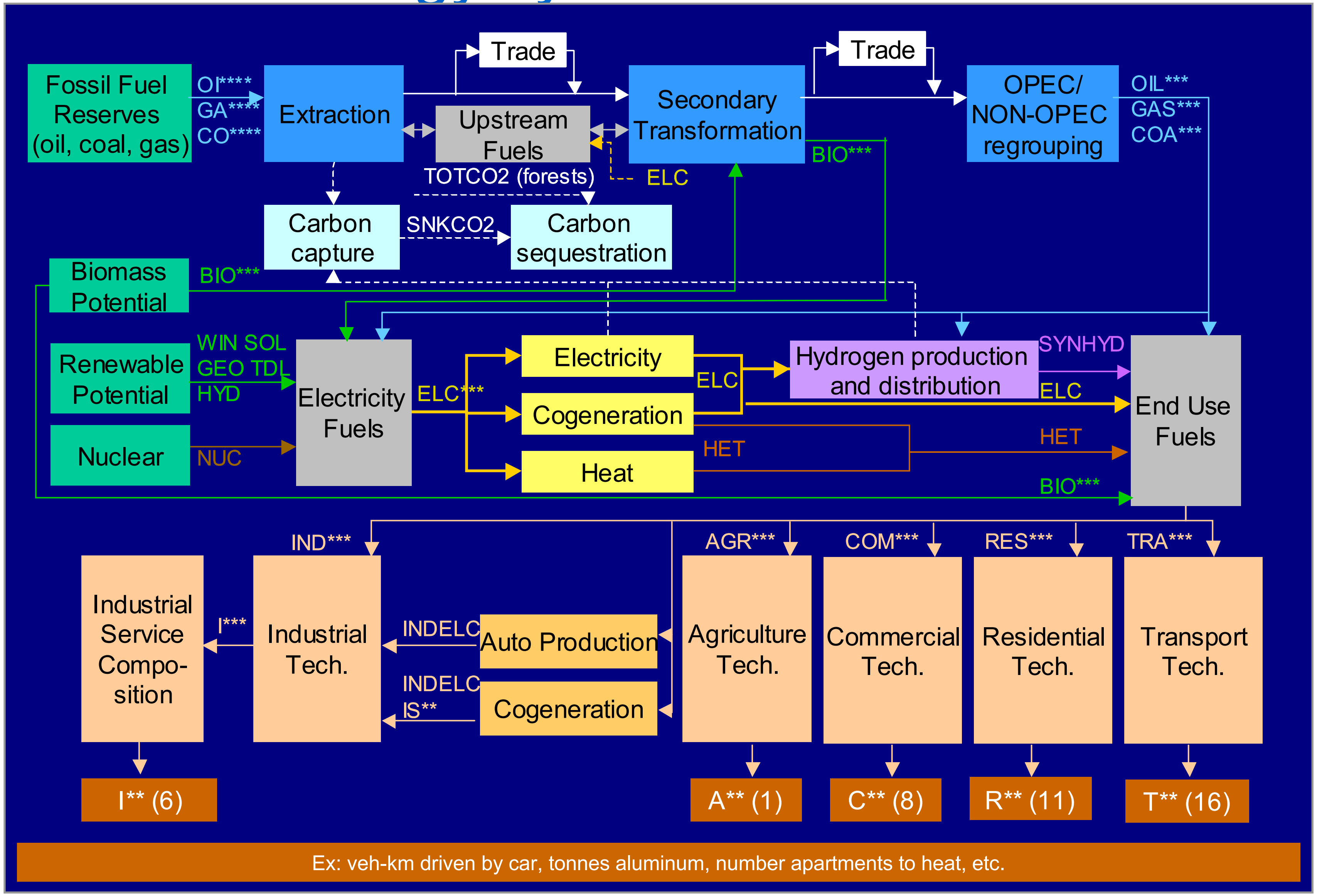
ETSAP Models and Tools



ETSAP-TIAM model

- TIMES model
  i. Dynamic partial equilibrium model approach with inter-temporal objective function (perfect foresight) minimizing total discounted system costs
  ii. Technologically detailed „bottom-up" model for each region
  iii. Covering energy flows from the useful energy demand over end-use sectors and conversion sector to the primary supply
- Time horizon 2000 – 2100
- 15 world regions with
  i. Bilateral trade in hard coal, pipeline gas, LNG, crude oil and petroleum products (distillates, gasoline, heavy fuel oil and naphtha)
  ii. Global trade in emission permits possible
- Emissions: CO2, N2O, CH4
  i. Carbon capture and sequestration (power generation and alternative fuel production)
  ii. Mitigation options for N2O and CH4
- Climate module (3-reservoir model for calculating atmospheric CO2 concentrations)
- Multi-stage stochastic programming (uncertainties in emission targets, demands, bounds)

Reference energy system



Carbon capture and storage in TIAM

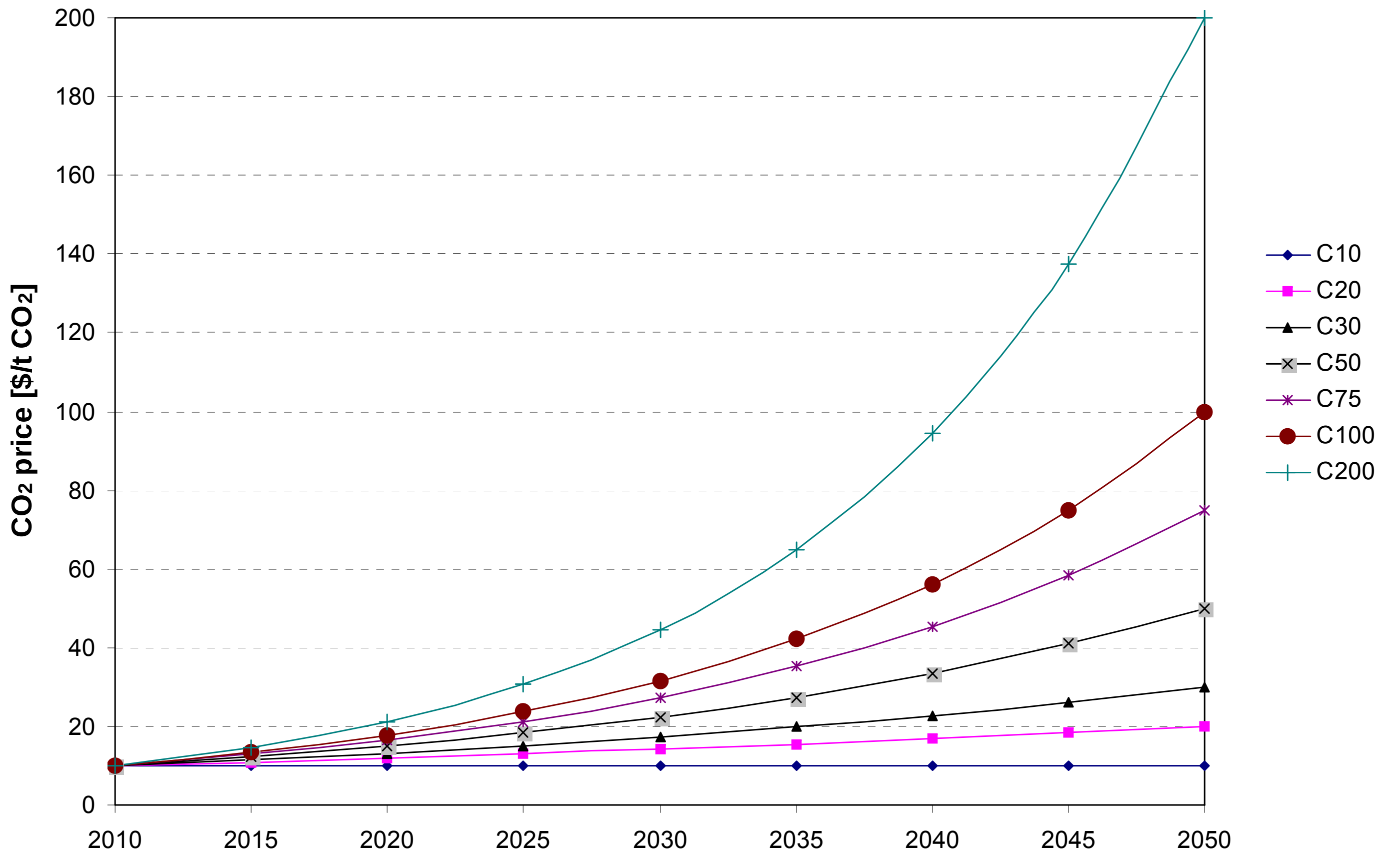
- Capture options:
  i. Upstream sector: hydrogen, FT fuels from natural gas and coal
  ii. Power generation:

Plant	Spec. investment cost increase rel. to non-capture plant	Efficiency loss
	%	%
Coal		
SC Postcomb	60-70	9-7
IGCC	22-35	9-6
SC Oxyfuel	65-85	10-8
Natural gas		
NGCC Postcomb	45-65	8-6
NGCC Oxyfuel	75-100	10-8

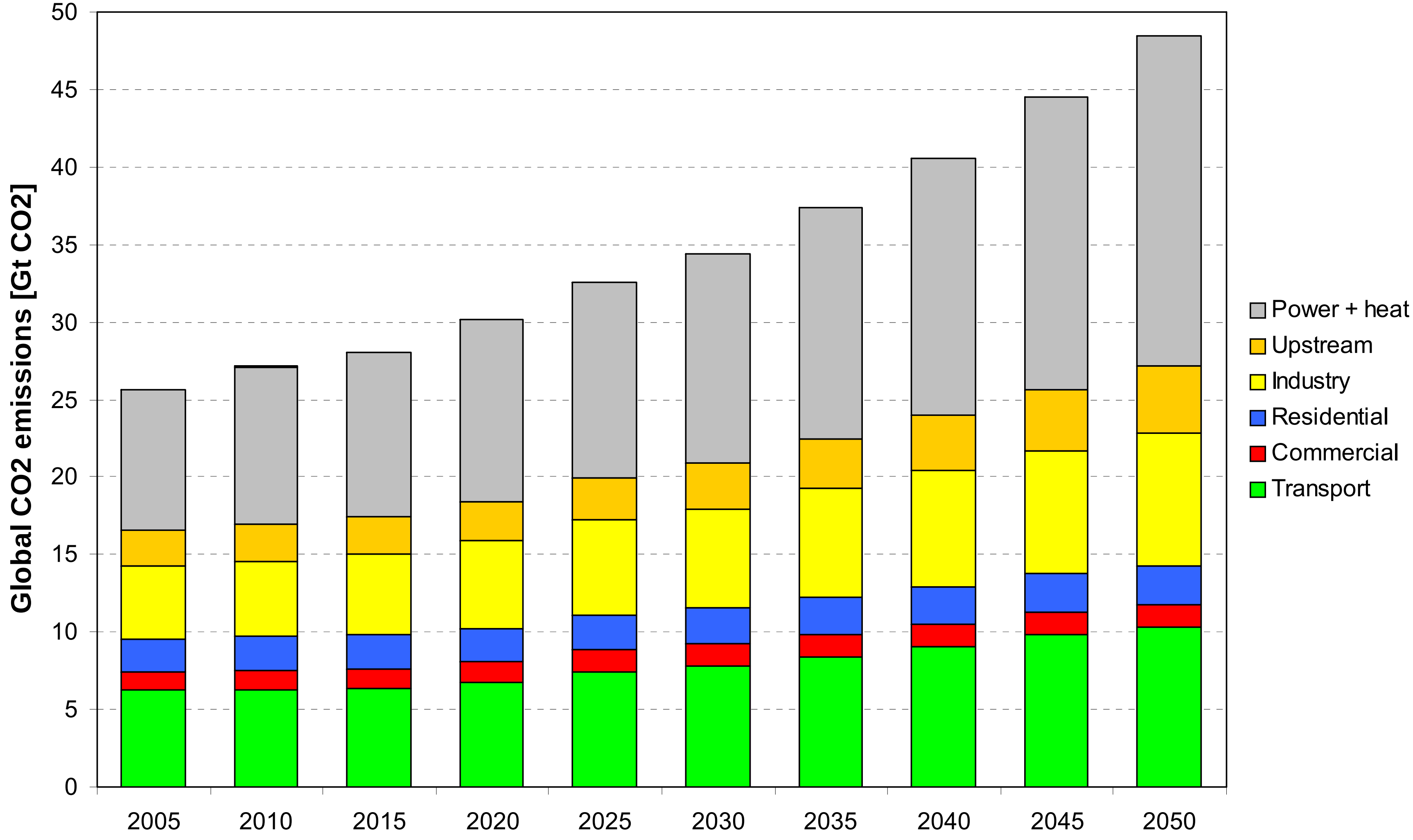
- Storage options:
  i. Depleted oil and gas fields (1-8 $/t)
  ii. Coal seams (20-40 $/t)
  iii. Deep saline aquifers (2-11 $/t)

Scenario analysis

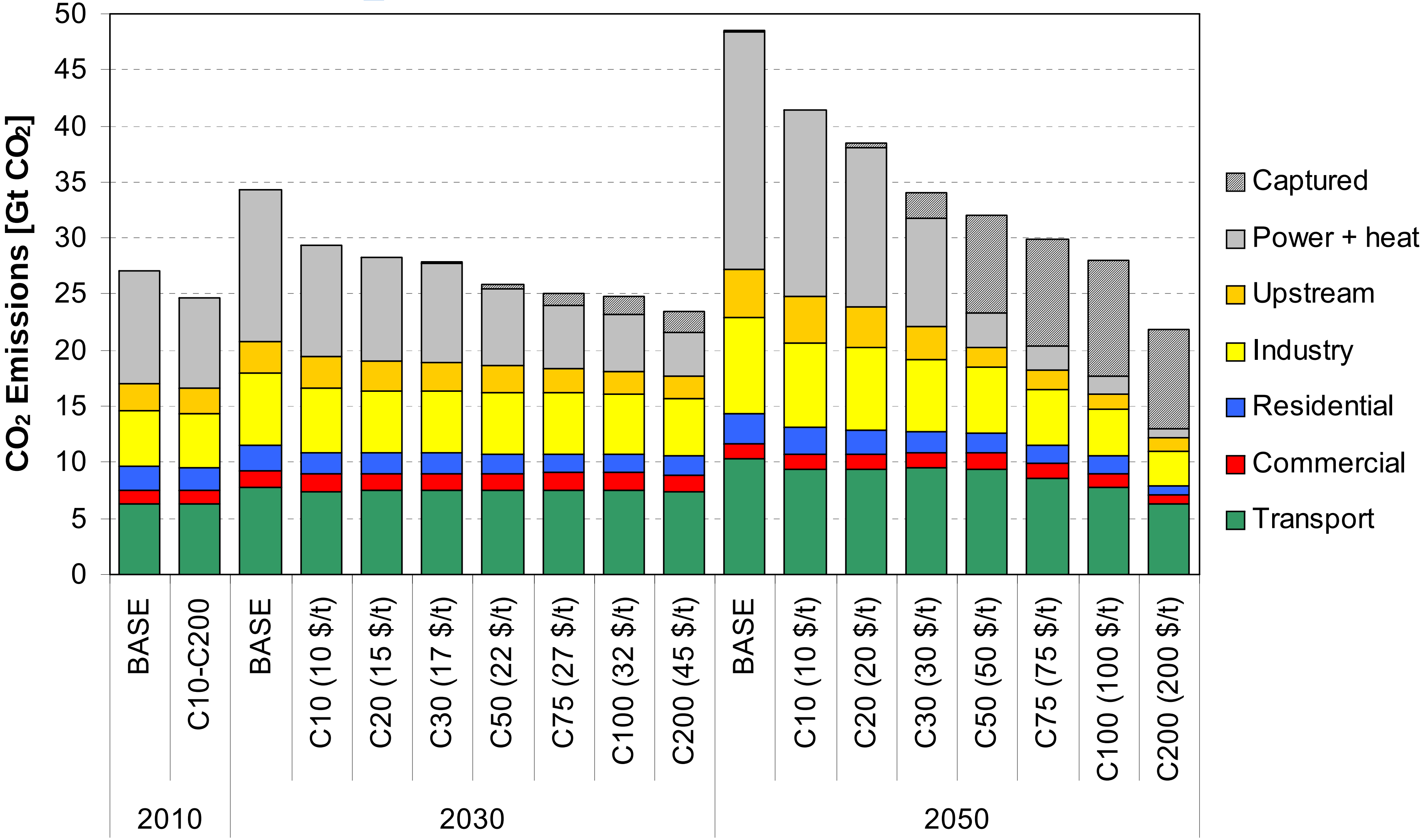
- Base case (no explicit CO2 reduction efforts)
- Variation of CO2 price with and without availability of CCS:



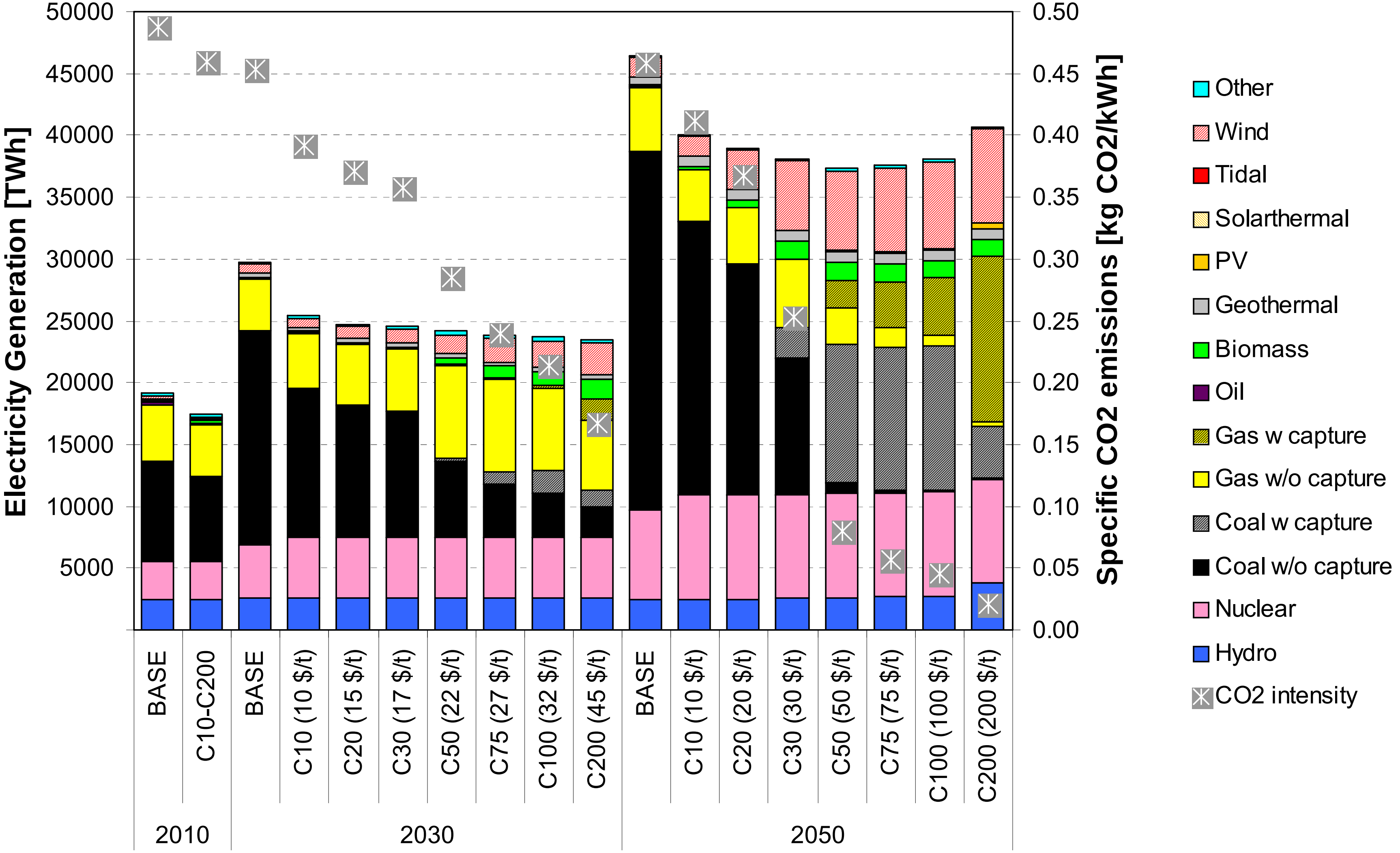
Global CO_2 emissions in base case



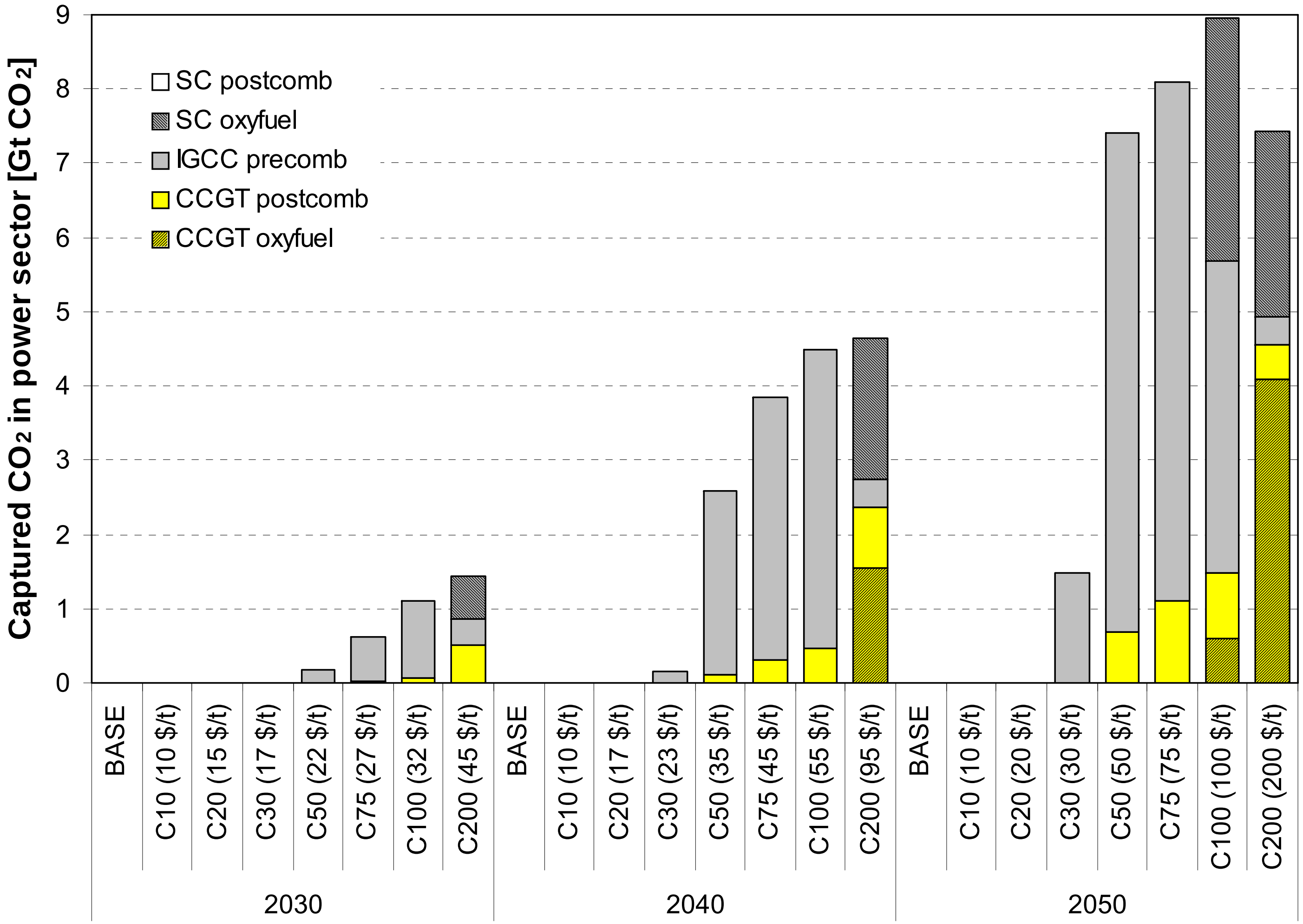
Sectoral CO_2 emissions



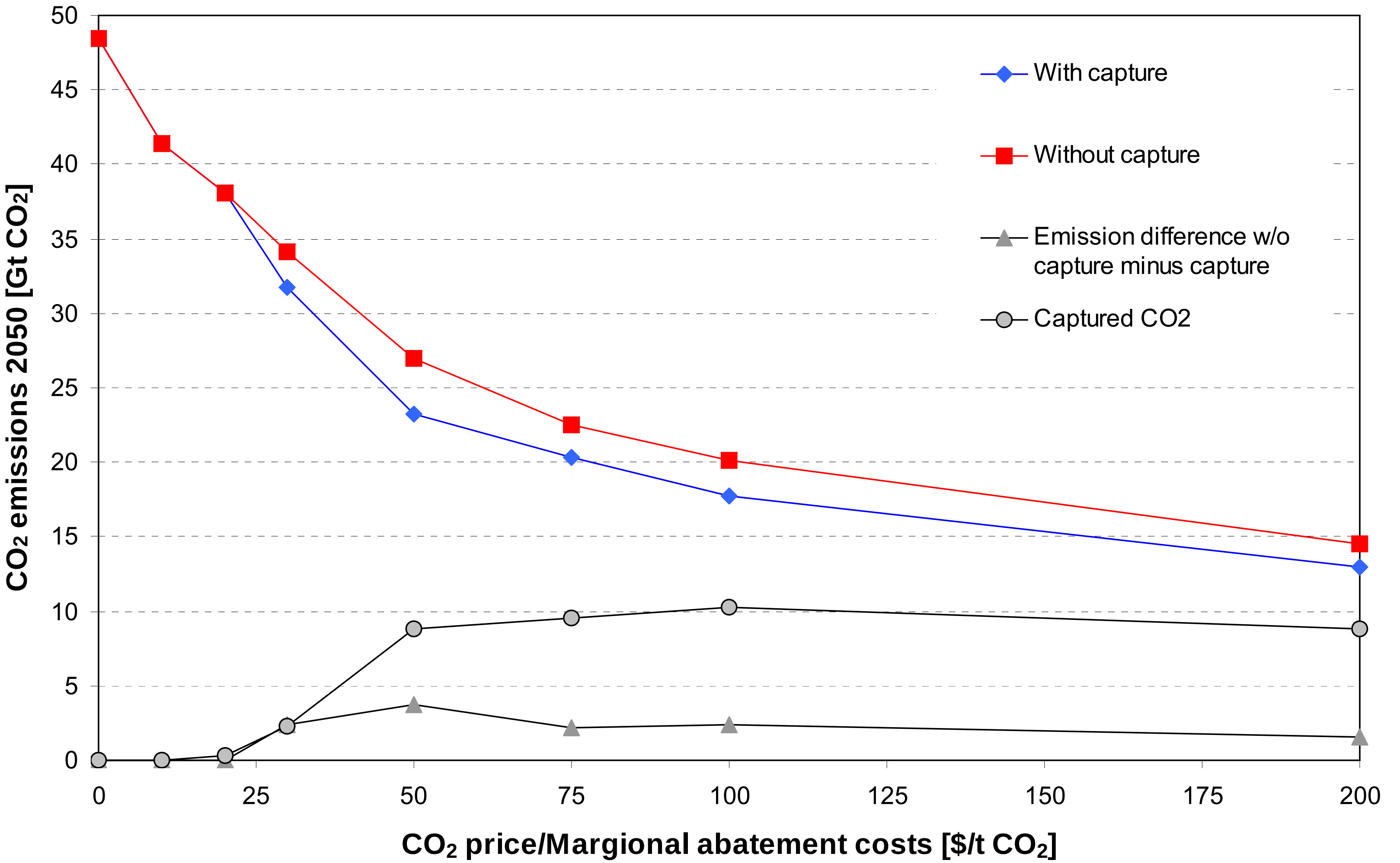
Electricity generation



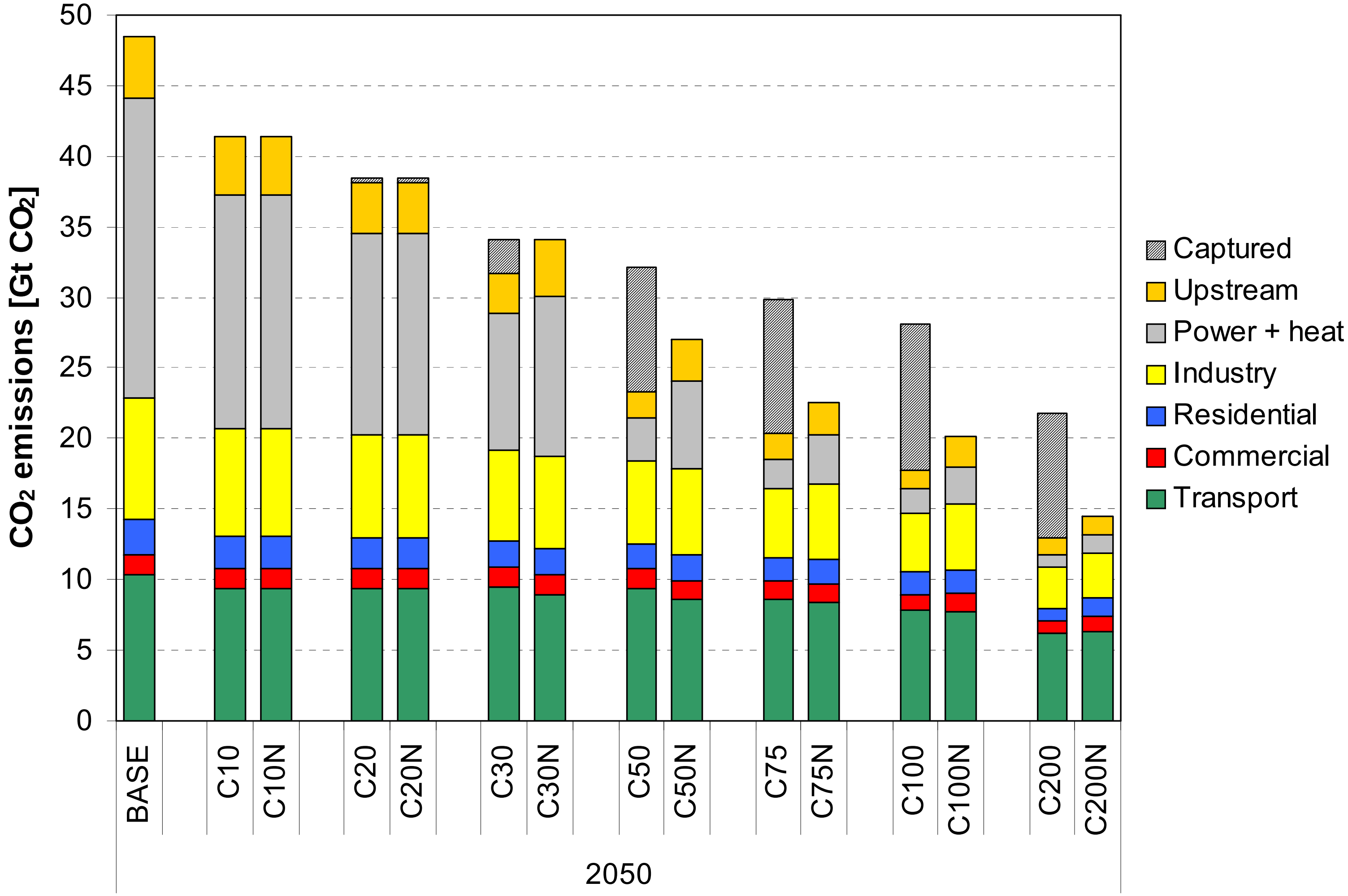
Captured CO_2 from electricity generation



Marginal abatement cost curves with and without capture

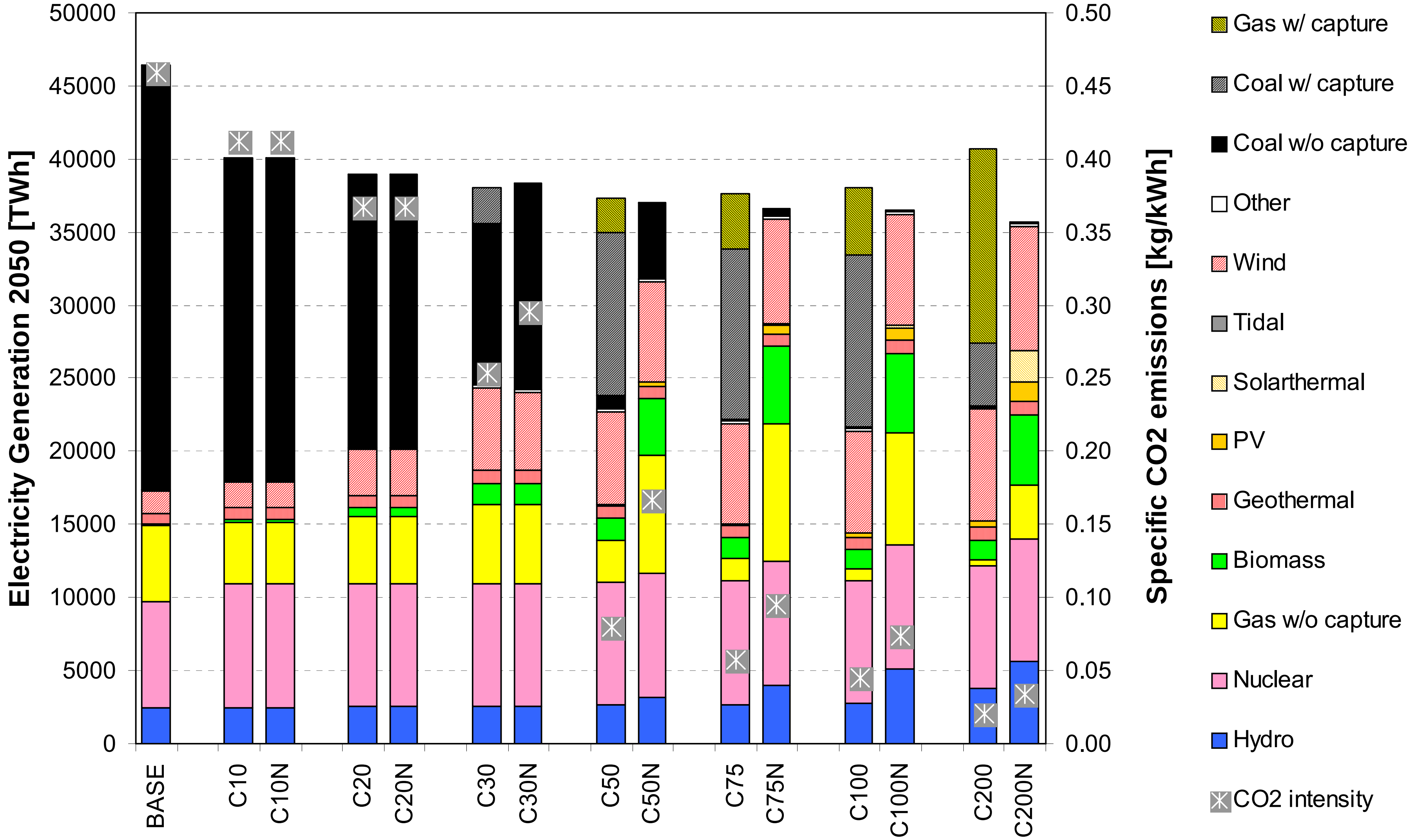


Comparison of sectoral CO_2 emissions



Additional annual costs in the case without capture to reach the same reduction target as with capture can be estimated to range at least from 75 (C30) to 310 Bill. $ (C200).

Comparison of electricity generation in 2050



Conclusions & Outlook

- CO_2 price variation with capture:
  i. CCS represents under technology assumptions a cost-effective CO_2 mitigation option at CO_2 prices above ca. 25 $/t CO_2
  ii. Up to 9 Gt in power generation and 1.4 Gt in alternative fuel production (FT fuel, hydrogen from coal) are captured in 2050
  iii. With increasing CO_2 price, gas capture plants become more economic compared to coal capture (sensitive to future technology characterization and regional gas price development!)
- Comparison with CO_2 price variation without capture:
  i. Non-availability of CO_2 capture yields higher CO_2 emissions, especially, at moderate CO_2 prices up to 50 $/t CO_2
  ii. At higher CO_2 prices, other mitigation options can partially compensate the absence of capture power plants by other generation options (gas, biomass, wind, hydro, PV and CSP in some regions, nuclear) and savings/substitutions in the end-use sectors
  iii. But at higher overall costs (flat area of marginal cost curve)
- Future work:
  i. Inclusion of CCS capture options in industry

Thank you!

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